MISSION ASSURANCE REQUIREMENTS FOR LIVING WITH A STAR/SPACE ENVIRONMENT TESTBEDS (SET) EXPERIMENTS

March 25, 2004

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The items below from the Mission Assurance Guidelines document dated March 14, 2003 are not addressed in the SET **Experiment** MAR. The reasons the items below are not addressed are because this mission is a low cost and high risk (Class D) mission. This MAR is for all the experiments that will fly in the SET Carrier. The total cost of each experiment is about $250K. The design/manufacturing costs for the GSFC carrier is 5 million dollars. This **Experiment** MAR requirements are structured to accept increased risk, as this is a low cost program compared to other Living With A Star (LWS) missions.

List of Items Not Included in the SET **Experiment** MAR:

(1) No Data Item Descriptions (DID) are included.
(2) The experiments have been asked to meet the intent of the ISO system.
(3) No System Safety Program Plan required
(4) No Software Safety Requirements levied
(5) No Maintainability Requirements levied
(6) No Reliability Program Plan required
(7) No Probabilistic Risk Assessment (PRA) required
(8) No Critical Items List (CIL) required
(9) No Fault Tree Analysis (FTA) required
(10) No Parts Stress Analysis required
(11) No Worst Case Analyses required
(12) No reliability Assessments/Predictions required
(13) No Software Reliability required
(14) No Trending Analysis required
(15) No Limited Life Plan required
(16) No Independent Verification and Validation (IV & V) language included
(17) No specific software Design Reviews (Design Reviews should include both hardware and software)
(18) No Assurance Status Reporting (hardware and software)
(19) Ground Data Systems Assurance is not applicable
(20) No formal risk management plan required, but each experiments must participate and support the Carrier Level Risk Management Program
(21) Only one Design Review required (CDR level review planned/No PDR)
(22) No Materials Usage Agreements (MUAs) required
(23) No Stress Corrosion Evaluation Form required
(24) Parts requirements are listed in an Appendix to this MAR. These requirements have been downgraded to guidelines for each experimenter. These guidelines are provided to each experimenter in the development of their own part requirements. These guidelines also include the radiation language.

However, it should be noted that each experimenter shall develop their own parts program, which receives GSFC approval.

CHANGE RECORD PAGE

DOCUMENT TITLE: LWS/SET Experiment Mission Assurance Requirements DOCUMENT DATE: 1/16/04			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Initial	June 20, 2003	ALL	Initial Release of Document
Rev. A	January 16, 2004	Section 2.1 -Moved design documentation section to the guidelines section Section 2.1 -Changed design documentation bullet "Test Plans and procedures development" to "Test Plans and procedures commensurate with the review" Section 2.3 -Removed "Master List of Instrument Numbers" Section 2.3 - Added a requirement for a **Assembly** and Test log Section 4.1 - Removed the requirement for packaging and marking to comply with **Interstate Commerce Commission rules and regulations** Section 6.1 -Moved Alerts section to guidelines Section 7.1, 7.2 and 7.3 -Moved Inorganic Materials, Materials Process Utilization and Materials Selection Requirements to guidelines section Section 7.7 - Changed Contractor to Experiment developer Section 12 - Moved the Reliability sentence "Experiment developers shall work with the SET Reliability Engineer in support of the FMEA for their experiment" to the guidelines section	- Revised document to create a guidelines section - Reformatted new document

		Section 17.0 - Removed last sentence: "These NASA disciplines include SQA, Software Safety, Software Reliability, Verification and Verification.	
		Section 16-Risk Management Requirements: Removed Reliability and Quality from the 1st sentence.	
		Section 16- Added "The Experiment developer shall participate in a weekly one-hour teleconference (as required) with the Risk Manager and Experiment Manager."	
		Section 16- Moved the following Risk Management Requirements to the Guidelines section: The Experiment developer shall: ? Implement a continuous program to capture, acknowledge, and document reliability and quality risks before they become problems ? Analyze identified risks to estimate the probability of occurrence, severity of impact, timeframe when mitigation actions are needed, and classify into sets of related risks and prioritize ? Develop plans to implement risk mitigation strategies and actions and assign appropriate resources ? Track risks being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies ? Control risks by performing risk closeout, re-planning, contingency planning, or continued tracking and execution of the current plan ? Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all	

		levels of the instrument/instrument-suite	

Rev. A con't	March 9, 2004	Section 2.3 Experiment Final Acceptance Data Package – Removed "and radiation tolerance" from bullet number three Removed "material review actions" from bullet number five	Incorporated comments from Experimenters
		Section 2.3 Handling and Shipping – Changed "The accompanying documentation…assembly and test log books" to "The accompanying documentation…"Experiment Final Acceptance Data Package"	
		Section 4.2 – Identification and Marking – Changed "lot date code" to "MM/YY of Manufacturer" from bullet number three. Removed "Part Identification, corresponding to the labels on Mechanical Interface Control Drawings" in bullet six.	
		Section 2.0 - Added "Appendix A" for clarification	
		Appendix A – Changed all "Shall" to "Should" statements	
		Section 2.0 – Added minimum required documentation for reviews	
		Section 4.1 Workmanship Standards – Removed certification to design requirement - Added "The developer may also submit workmanship samples prior to fabrication of flight hardware, which shall be approved by the GSFC SET SAM"	
		Section 7.0 - Failure Reporting –Changed notification of failures from 24 hours to 1 business day.	

		Section 8.0 Photographic Requirements – Changed paragraph "The Experiment developer shall provide **a photographic record** of each electronic board of their experiment. Photographs shall be **provided of the end item**, clearly showing all critical details". To read "The Experiment developer shall provide final assembly and sub-assembly photographs of each electronic board of their experiment, clearly showing all critical details".	
		Section 15.0 Risk Management – Removed requirement for" weekly one-hour" teleconferences	
		Appendix A – Added "If the Experiment Developer cannot meet the guidelines herein, the item not met could be identified as a Risk and will require mitigation from SET Project personnel"	

Table of Contents

1.0 GENERAL

The purpose of this document is to present the Safety and Mission Assurance (SMA) requirements necessary for the Experiments to be flown on the Space Environment Testbeds (SET) Carrier.

The SMA requirements for the SET Mission are structured to accept increased risk, as this is a low cost program compared to other Living With A Star (LWS) missions.

The Experiment developer shall use this Mission Assurance Requirements (MAR) document in developing their SMA approach, and realistically addressing the cost associated with these tasks. The quality program shall meet the intent of ANSI/ASQC Q9001-2000, "Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing."

The Experiment developer shall be required to meet the requirements of this Mission Assurance document through all phases of activity. All requirements imposed during SET experiment proposal acceptance, award and up to Experiment delivery to NASA are incorporated into the requirements of this MAR.

The guidelines in Appendix A are intended to assist the Experiment developer in developing their parts program and provide additional information on required reviews. If the Experiment Developer cannot meet the guidelines in Appendix A, the item could be identified as a Risk and will require mitigation from SET Project personnel.

If the experiment developer cannot meet any of the requirements herein, the experiment developer must submit a waiver request or deviation to NASA/GSFC for consideration and approval.

2.0 EXPERIMENT REVIEWS AND DATA PACKAGES

The Experiment developer's shall conduct reviews of their experiment development. Review team participants shall include independent experts from the experiment developer's institution and SET project personnel. Each experiment shall have the following set of reviews and provide documentation (if applicable) listed below for each review:

- Experiment Requirements Review (RR) – Discussions to support Science Requirements, Mission Objective; Investigation Requirements; Constraints; Technical/Performance Requirements; Organizational Interfaces; Technical Interfaces; System Drivers; Safety Considerations; Risk Areas; Proposed Design Approach (System Design, Mechanical, Electrical, Thermal, Software, Ground Support Equipment (GSE), Operations, Planned Test Program)

- Experiment Design Review (DR) - Final design and interfaces by means of block diagrams, power flow diagrams, signal flow diagrams, interface circuits, layout drawings, software logic flow and timing diagrams, design language, modeling results, breadboard (and engineering model test results, if applicable)

- Experiment Pre-Environmental Review (PER) - Test verification matrix, including measurement tolerances, stimuli, contamination control, and facility readiness, the results of sub-level testing, results since the last review, and results from the Comprehensive Performance Test (CPT), failure free operating time

- Experiment Pre Ship Review (PSR) - results of environmental, system testing, calibration and end item performance

These reviews may be accomplished through a teleconference with Set Project personnel. A follow-up teleconference review may be required to address any open items from the reviews. Refer to Appendix A (guidelines section) for more information on the individual reviews.

2.1 QUALIFICATION AND ACCEPTANCE TEST PLAN/PROCEDURE

The Experiment developer shall produce a Qualification and Acceptance Test Plan/Procedure (Q/ATP) for the Engineering and Flight Experiment models in accordance with the design, test and environmental requirements. The Q/ATP shall be made available to GSFC for review. At a minimum, the Q/ATP tests shall be conducted on the designated flight unit.

2.2 EXPERIMENT FINAL ACCEPTANCE DATA PACKAGE

The Experiment developer shall deliver a data package that captures the "as built" configuration and test of the delivered flight units. The Flight Experiment Data Package shall contain the following as a minimum:

- Unit identification data, part/serial numbers
- As-built configuration list and copies of applicable drawings
- List of parts/devices used in the hardware, with traceability information
- List of materials and processes used in the hardware
- Software version
- Assembly and Test Log Book including total operating time and cycle records, "As run" test procedures with test results, summary information relating to discrepancies (component removal and replacement), anomalies, failures, and their disposition at first power, summary information listing functional and performance data, inspection history
- Experiment level photographs
- List of open items with reasons for their open status and proposed closure dates

3.0 HANDLING, STORAGE, PRESERVATION, MARKING, LABELING, PACKAGING AND SHIPPING

Deliverable investigation flight products shall be stored, preserved, marked, labeled, packaged, and packed to prevent loss of marking, deterioration, contamination, or damage during all phases of the program. Stored and stocked items shall be controlled and be subject to quality surveillance.

3.1 HANDLING AND SHIPPING

The Experiment developer shall ship flight hardware items only after inspection and/or written authorization from the GSFC Contracting Officer Technical Representative (COTR). The Experiment developer shall provide appropriate environmentally controlled shipping containers for all deliverable hardware.

The Experiment developer shall be responsible for the protection of the deliverable investigation flight items and associated Ground Support Equipment (GSE) during handling, transporting and delivery. The Experiment developer shall provide all materials and personnel required to design, fabricate, and test the necessary handling fixtures, shipping containers, packaging material, and labeling to protect the completed carrier flight units, GSE and Test Equipment against contamination, excessive condensation and moisture, and damage during handling, transportation, and delivery. The shipping containers shall include temperature, and humidity indicators. Prior to shipping, the Experiment developer's quality assurance personnel shall ensure that:

- Fabrication, inspection, and test operations have been completed and accepted.
- All deliverable products are identified and marked in accordance with requirements. Shipping containers carrying flight hardware are clearly labeled as such.
- The accompanying documentation (Experiment Developer's Shipping and Property Accountable Form and Experiment Final Acceptance Data Package) has been reviewed for completeness, identification, and quality approvals.
- Packaging and marking of deliverable products are adequate to ensure safe arrival and ready identification at their destinations.
- The loading and transporting methods are in compliance with those designated in the shipping documents.
- Integrity seals are on shipping containers.

Special handling instructions for receiving activities are provided where appropriate, including proper labeling of containers and related documents to provide evidence of this verification. The experiment developer may use "best commercial practices" for packaging and shipping and has responsibility for any damage incurred during shipment.

3.2 IDENTIFICATION AND MARKING

Marking of the assembled flight hardware shall, as a minimum, contain part number, serial number, and revision level. All connectors shall be uniquely identified. Marking of the part shall not induce any stresses; i.e., steel stamp or etch ink stamp or equivalent, which meets out gassing and contamination requirements, is acceptable.

The Experiment flight units shall be permanently labeled with the required information (this information can be silk screened or rubber stamped) and individually packaged in sealed ESD protective bags which shall be tagged with the unit's identification and marking. The tag and label shall contain the following information as a minimum:

- Manufacturer's Name
- Manufacturer's Part Number and latest revision letter
- MM/YY of Manufacturer
- Unique Serial Number
- Nomenclature of the unit

4.0 QUALITY ASSURANCE

The Experiment developer shall develop and implement an appropriate Mission Assurance Program for the flight hardware, software, and ground support equipment. The experiment developer shall define and implement a quality system based on ANSI/ISO/ASQC Q9001-1994 that meets the intent of ISO 9001. The experiment developer, together with the Goddard Space Flight Center Systems Assurance Manager (GSFC SAM), shall continually review and verify the proper implementation of this mission assurance program. **The Experiment developer shall contact the GSFC Systems Assurance Manager (SAM) concerning any Quality related issues.**

In the Mission Assurance Program, the Experiment developer shall demonstrate how the experiment is in compliance with its stated Proposal objective(s) and provide sufficient details to illustrate the experiment's capability to meet or exceed the Proposal's stated mission success levels.

4.1 WORKMANSHIP (http://workmanship.nasa.gov/wkstds.jsp)

The Experiment developer shall use the following NASA workmanship processes on flight hardware:

- NASA-STD-8739.3, Soldered Electrical Connections

- NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring
- NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies,
- ANSI/ESD S20.20-1999, Standard for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)
- NASA-STD-8739.2, Workmanship Requirements for Surface Mount Technology,
- 561-PG-8700.2.1, Flight Field Programmable Gate Array Design Guidelines
- IPC-2221, Generic Standard on Printed Board Design
- IPC-6011, Generic Performance Specification for Rigid Printed Boards
- IPC-6012, Qualification and Performance Specification for Rigid Printed Boards – Supplemented with GSFC/S-312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses

However, the developer's internal workmanship standards, alternate workmanship standards, or commercial practices may be utilized if they meet the intent of the NASA standards and are approved prior to use by the GSFC SET SAM.
The developer may also submit workmanship samples prior to fabrication of flight hardware, which shall be approved by the GSFC SET SAM.

The Experiment developer shall provide the SET project with printed wiring board (PWB) coupons and associated test reports for evaluation and approval by the GSFC coupon test laboratory personnel. Coupon acceptance shall be obtained from GSFC prior to board population. The experiment developer personnel working on flight hardware shall be certified as having successfully completed the required courses, prior to handling any flight hardware. This includes, but is not limited to, the aforementioned workmanship and Electro-Static Discharge (ESD) awareness courses.

5.0 PARTS

The experiment developers shall interface with the SET Parts Engineer for assistance with the Guidelines in Appendix A.

5.1 PARTS LIST (PL)

The experiment developer shall submit a Parts List (PL) for their flight hardware. The PL will list all parts planned for use in flight hardware, regardless of their approval status.

The initial PL and subsequent updates will be submitted to the GSFC for approval. An As-Built Parts List (ABPL) shall also be maintained and submitted to the GSFC for inspection as part of the Final Acceptance Data Package. The PL shall be a

composite of the parts selection for each circuit design, including EEE parts, and should include, as a minimum, the following information:

- Complete Procured part number
- Generic Part Number
- Part name or functional description
- Serial number, if applicable
- Manufacturer
- Lot Date Code ("as built" list only)
- Part specification control drawing number
- Need Quantities
- Part use locations to the subassembly level
- Radiation Tolerance

6.0 MATERIALS LISTS

NASA Reference Publication 1124, Rev. 4 entitled "Out gassing Data for Selecting Spacecraft Materials" (http://outgassing.nasa.gov) shall be used as a guide for materials selection.

The experiment developer shall maintain a list of materials, processes, and appropriate usage records prior to and during the hardware development for review by the GSFC. This "as-built" list shall be maintained and delivered as part of the Final Acceptance Data Package.

6.1 COMPLIANT MATERIALS

The experiment developer shall use compliant materials in the fabrication of flight hardware to the extent practicable. In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria identified as follows:

- Hazardous materials requirements, including flammability, toxicity and compatibility as specified in Eastern and Western Range 127-1 Range Safety Requirements.

- Vacuum Out gassing requirements as defined in NASA Reference Publication 1124, Rev. 4. A list of material out gassing data shall be established, and reviewed and approved by the GSFC. Only materials that have a total mass loss (TML) <1.00% and a collected volatile condensable mass (CVCM) <0.10% shall be used unless a waiver is submitted and granted by the GSFC.

- Stress corrosion cracking requirements as defined in MSFC-STD-3029. Conventional applications or usage of materials is the use of compliant materials in a like manner for which there is extensive satisfactory aerospace heritage.

6.2 NON-COMPLIANT MATERIALS

Materials that do not meet the requirements of the applicable selection criteria, or used in an unconventional application shall be considered to be a non-compliant material. The proposed use of a non-compliant material requires approval by the GSFC SET Project personnel prior to use.

"Off-the-shelf" hardware, for which a detailed materials list is not available, and where the included materials cannot be easily identified and/or changed, will be treated as non-compliant."

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage will be considered a non-conventional application. In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods and approved by the GSFC.

6.3 LIMITED SHELF-LIFE MATERIALS

Materials that have a limited shelf life shall be controlled and documented by the developer. At a minimum, the records shall identify the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf life, and expiration date. Materials such as o-rings, rubber seals, bonding/thermal adhesives, tape, uncured polymers, lubricated bearings and paints will be included. The use of materials whose date code has expired requires that each contractor demonstrate, by means of appropriate tests, that the properties of the materials have not been compromised for their intended use; such materials must be approved by the GSFC by means of a waiver. When a limited-life piece part is installed in a subassembly, the subassembly item will be documented in the Experiment developers Final Acceptance Data Package.

6.4 RAW MATERIALS USED/PURCHASED

Raw materials purchased by the experiment developer shall be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance.

6.5 FASTENERS

If applicable to the experiment, reference and use the GSFC Specification GSFC-541-PG-8072.1.2.

7.0 FAILURE REPORTING

ANSI//ISO/ASQC Q9001-1994, paragraph 4.13.2, defines failure report requirements as follows:

- Any departure, or suspected departure, from design, performance, testing, or handling requirements that affects the function of flight equipment shall be

immediately documented. Failures in ground support equipment that interfaces with flight equipment shall also be immediately documented.

Reporting of failures shall begin with the first mechanical or electrical test of the item to be delivered. The experiment developer shall contact the GSFC SAM in the event of major failures (within 1 business day) via email or voice mail. The GSFC SAM will assist with the non-conformance report, disposition and closure.

If the experiment contains software, the developer shall implement a process for Software Problem Reporting and Corrective Action that address reporting, analyzing and correcting software non-conformances throughout the experiment's life cycle.

8.0 PHOTOGRAPHIC REQUIREMENTS

The Experiment developer shall provide final assembly and sub-assembly photographs of each electronic board of their experiment, clearly showing all critical details.

Each photograph shall be identified with assembly number, serial number, description (e.g. name of the assembly) date of photo, and the developer's company name or logo. Digital photographs are acceptable as long as the email contains assembly number, serial number, and description (e.g. name of the assembly).

9.0 CONFIGURATION MANAGEMENT

The Experiment developer shall have a configuration management system in place. The Experiment developer's configuration system shall ensure that all applicable changes are reviewed in a systematic manner to determine the validity and impact on performance schedule and cost.

If an experiment contains software, the developer shall develop and implement a Software Configuration Management system that provides baseline management and control of software requirements, design, source code, data, and documentation.

10.0 RELIABILITY

The reliability program will include the following aspects: (1) parts, materials, and process controls; (2) design and development reviews and oversight; (3) thorough testing and validation.

The Experiment developer shall support the SET project in performing a Failure Modes and Effects Analysis (FMEA) for the carrier. The intent of the FMEAs is to eliminate potential failure modes from the carrier that could be detrimental to the bus or to the experiments and to eliminate potential failure modes from individual experiments that could be detrimental to the carrier or other experiments.

11.0 SURVEILLANCE OF THE EXPERIMENTER

The Experiment developer and their subcontractors and suppliers work activities and operations are subject to evaluation; review, survey and inspection by a GSFC or GSFC designated (DCMA/SAC) Systems Assurance representative.
The Experiment developer shall make available to the GSFC Systems Assurance representative documents, records, equipment, as well as access to working areas within his facilities that are required by the representative to perform his overview activities. The GSFC SET SAM or GSFC designated Systems Assurance representative shall conduct a pre-arranged facility visit at each Experiment developer's facility.

12.0 SAFETY

The Experiment developer's system safety program shall be initiated in the concept phase of design and continue throughout all phases of the mission. Each experiment developer shall support the carrier developer (GSFC) with all the safety documentation needed to satisfy the requirements for the appropriate launch vehicle. Each developer shall provide technical support to the SET Project for safety working group meetings and technical meetings, as necessary. The GSFC System Safety Engineer shall certify safety compliance prior to the Carrier Pre-Ship Review. The system safety program shall accomplish the following:

- Provide for the early identification and control of hazards to personnel, facilities, support equipment, and the flight system during all stages of project development including design, fabrication, test, transportation and ground activities. The program shall address hazards in the flight hardware, associated software, ground support equipment, operations, and support facilities, (and shall conform to the safety review process requirements of NASA-STD-8719.8, "Expendable Launch Vehicle Payloads Safety Review Process Standard".)
- Meet the system safety requirements of EWR 127-1 "Range Safety Requirements Eastern and Western Range" and KHB 1710.2, "Kennedy Space Center Safety Practices Handbook" and NPR 8715.3 NASA Safety Manual.
- Meet the baseline industrial safety requirements of the institution.

13.0 ORBITAL DEBRIS ASSESSMENT

Each Experiment developer shall provide information to GSFC in order to support the development of an Orbital Debris Assessment. The experiment developer shall work with the GSFC Safety Engineer in order to assure requirements of the safety policy are met.

14.0 CONTAMINATION

The Experiment developer shall follow the Carrier Contamination Control Plan (CCP) that describes the procedures that will be followed to control contamination.

It shall establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. Experiment developers will identify any specific contamination requirements. In general, all mission hardware should be compatible with the most contamination-sensitive components.

15.0 RISK MANAGEMENT REQUIREMENTS

All identified risks shall be documented and reported on in accordance with the SET Project's Risk Management Plan. Although not all risks will be fully mitigated, all risks shall be addressed and mitigation and acceptance strategies will be agreed on in accordance with the SET Project Risk Management Plan and at appropriate mission reviews.

The Experiment developer shall provide input into the SET Project's Risk Management Program. Risk Management applies to all software and hardware products and processes (flight and ground) in order to identify, analyze, plan mitigation actions, track, control, and communicate risks. The Experiment developer shall participate in teleconference (as required) with the Risk Manager and Experiment Manager. Report all outstanding risk items at all Management and Design reviews.

16.0 SOFTWARE ASSURANCE

If the experiment contains software, the experiment developer shall perform software assurance functions for all flight and ground system software. This applies to software and firmware developed under this contract, including Government off-the-shelf (GOTS) software, modified off-the-shelf (MOTS) software, and commercial off-the-shelf (COTS) software.

The experiment developer shall ensure that software lifecycle processes and products conform to requirements, standards, and procedures. The experiment developer shall ensure that any software safety requirements, identified as part of system safety, are documented, traced, and controlled throughout the life cycle.

17.0 VERIFICATION REQUIREMENTS

Each developer shall conduct a verification program to ensure that the flight system meets the specified mission requirements. The program shall consist of functional demonstrations, analytical investigations, physical measurements and tests that simulate all expected environments. The developer shall provide adequate verification documentation including a verification plan and matrix, environmental test matrix and verification procedures. If the experiment contains software, then these verification plans, matrices, and procedures shall include software.

APPENDIX A: GUIDELINES

PARTS PROGRAM GUIDELINES: The following are guidelines, not requirements, for each experiment developer to follow in the development of their own part requirements. If the Experiment Developer cannot meet the guidelines herein, the item could be identified as a Risk and will require mitigation from SET Project personnel

1) PARTS CONTROL BOARD
2) PARTS CONTROL BOARD (PCB) MEETINGS
3) PARTS SELECTION AND PROCESSING
4) CUSTOM DEVICES
5) DERATING
6) RADIATION HARDNESS (MODULAR DESIGN APPROACH)
7) SCREENING AND QUALIFICATION
    7a) CAPACITORS SCREENING
8) CUSTOMER SOURCE INSPECTION (CSI)
9) DESTRUCTIVE PHYSICAL ANALYSIS (DPA)
10) PARTS AGE CONTROL
11) ALERTS
12) PARTICLE IMPACT NOISE DETECTION (PIND)
13) PARTS TRACEABILITY
14) ORBITAL DEBRIS ASSESSMENT
15) RETENTION OF TEST DATA AND SAMPLES
16) INORGANIC MATERIALS
17) MATERIALS PROCESS UTILIZATION
18) MATERIALS SELECTION REQUIREMENTS
19) RELIABILITY
20) RISK MANAGEMENT

1) PARTS CONTROL BOARD

The Contractor may establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB may be responsible for the review and approval of all EEE parts, for conformance to established criteria (including radiation effects), and for developing and maintaining a Project Approved Parts List (PAPL). In addition, the PCB is responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. The GSFC Project Parts Engineer (PPE) and Experiment's Part Engineer may be permanent working members of the PCB. The GSFC SET PPE and Carrier subsystem designer may participate in all PCB meetings. The SAM and Project Leader (or their delegates) may attend as necessary. The PPE may assure that additional engineering knowledge and skills are represented at meetings, as required.

If there are any parts issues that cannot be resolved at the PCB level, the issues may be elevated to the SET Project Manager for disposition.

2) PARTS CONTROL BOARD (PCB) MEETINGS

PCB meetings may be convened on a regular basis or as needed. The SET Project Parts Engineer (PPE) will participate in all PCB meetings and should be notified at least 5 days in advance of all upcoming meetings. Notification should, as a minimum, include a proposed agenda and Parts Identification List of candidate parts. The contractor should maintain meeting minutes or records that document all decisions made and a copy should be provided to GSFC within five business days of convening the meeting. GSFC will retain the right to overturn decisions involving nonconformances within ten days after receipt of meeting minutes.

3) PARTS SELECTION AND PROCESSING

EEE parts should be selected to optimize design and reliability. As a baseline, parts should be selected and processed in accordance with GSFC EEE- INST-002: Instructions for EEE Parts selection,-Screening, Qualification and Derating. Due to the severe radiation environment of SET, the use of commercial and plastic components is prohibited. Where hermetic, high reliability devices are not available, exceptions can be granted by GSFC. Parts selected from GSFC PPL, MIL-STD-975 or the NASA Parts Selection List (NPSL) is preferred. With Project Manager concurrence, parts that comply with these requirements should be acceptable for procurement without PCB review. All other EEE parts should be selected, manufactured, processed, screened and qualified, as a minimum, in the same manner as the nearest applicable quality level 3 device(s). GSFC PPL-21, Appendix C, may also be used as a guideline for the required screening.

A procurement specification may be required for parts in the category based on the recommendation of the Parts Engineer. These specifications should fully identify the item being procured and should include physical, mechanical, electrical, and environmental test requirements and quality assurance provisions necessary to control manufacture and acceptance. Screening requirements designated for the part can be included in the procurement specification. They should specify test conditions, failure criteria, and lot rejection criteria. For lot acceptance or rejection, the Percentage of Defective Allowable (PDA) in a screened lot should be in accordance with that prescribed in the closest military part specification.

4) CUSTOM DEVICES

All custom or advanced technology devices such as custom microcircuits, hybrid microcircuits, Multi-Chip Module (MCM's), Application Specific Integrated Circuits (ASIC's), etc., should be subjected to a design review by GSFC. The design review will address, at a minimum, derating of elements, method used to assure each element reliability, assembly processes and materials, method for assuring adequate thermal matching of materials, radiation hardness and screening, precap source inspection and qualification requirements.

5) DERATING
All EEE parts should be used in accordance with the derating guidelines of GSFC PPL-21. The experiment developer's derating policy may be used in place of the PPL guidelines if approved by GSFC.

6) RADIATION HARDNESS (MODULAR DESIGN APPROACH)
(Note: Each SET launch may have a unique orbit and corresponding radiation characteristics; therefore, the following are radiation hardness requirements to be used for a generic design that is readily adaptable to different spacecraft requirements.)

The radiation environment consists of three separate effects, those of total ionizing dose, displacement damage and single-event effects. EEE Parts should be capable of meeting 100Krads(si) Total Ionizing Dose (TID), Linear Energy Transfer Threshold (LETth) of > 37 MeV/mg/cm^2 for soft errors from single events (SEU, Single Event Transient, etc.) and a LETth of > 80 MeV/mg/cm^2 for potentially destructive events (SEL, SEB, SEGR, etc.). This latter category includes events deemed as non-destructive SELs that may have latent damage issues. Displacement damage should also be considered for parts susceptible to this type of effect. Parts that are not guaranteed to meet the above radiation requirements will be considered non-standard. SET Parts Control Board and Radiation Effects Group will review and approve exemptions to the above requirements and analyze appropriate mitigation circuits.

7) SCREENING AND QUALIFICATION
EEE parts should be screened and qualified in accordance with 311-INST-001, Parts Quality Level 3. The PPE will develop or review contractor's screening and qualification plan. Manufacturer's data may be acquired and reviewed for acceptability. If approved by GSFC, such tests need not be repeated during additional screening and qualification testing.

7a) CAPACITORS SCREENING
Surge Current Screening for Tantalum Capacitors - All solid tantalum capacitors used in filtering applications should be subjected to surge current screening. Chip devices (CWR06/CWR09, for example) should receive testing in accordance with MIL-PRF-55365 (+25^{o}C only). This testing can be performed at the manufacturer's facility by adding an "A" suffix to the standard military part number. Leaded devices (M39003/01 for example) should receive testing in accordance with MIL-PRF-39003/10.

Dielectric Screening for Ceramic Capacitors - Ceramic capacitors used in circuits at or below 10V should be rated at 100V or greater, (does not apply to MIL-PRF-123 capacitors). Each lot of capacitors rated below 100V should have samples subjected to Humidity Steady State Low Voltage testing (85^{o}C and 85% relative

humidity) in accordance with MIL-PRF-123 (12 piece sample for each lot/date code). Following humidity exposure, a Destructive Physical Analysis (DPA) should be performed in accordance with MIL-PRF-123 (sample size per GSFC specification S-311-M-70, for each lot/date code).

8) CUSTOMER SOURCE INSPECTION (CSI)
CSI should consist of pre-cap visual inspection, and/or assembly traveler review and data review. It may be expanded to include pre-award audits and design reviews for custom hybrid microcircuits and complex components. CSI requirement for other devices will be based upon a history of known problems with a particular part.

9) DESTRUCTIVE PHYSICAL ANALYSIS (DPA)
Parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size and criteria should be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. Contractor's procedures for DPA may be used in place of S-311-M-70 and should be submitted with the PCP for concurrence prior to use. The PCB on a case-by-case basis should consider variation to the DPA sample size requirements, due to part complexity, availability or cost.

10) PARTS AGE CONTROL
Parts drawn from controlled storage after five (5) years from the date of the last full screen should be subjected to a re-screen and sample DPA per PCB recommendation. Alternate test plans may be used as determined and approved by the PCB on a case-by-case basis. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination should not be used.

11) ALERTS
Each Experiment developer should be responsible for review and disposition of Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use. In addition, any NASA Alerts and Advisories provided to the contractor by GSFC should be reviewed and dispositioned. Alert applicability, impact and corrective actions should be documented and submitted to GSFC for review.

12) PARTICLE IMPACT NOISE DETECTION (PIND)
All EEE devices with internal cavities should be subjected to 100% PIND screening, in accordance with the applicable specification in GSFC-311-INST-001. Any device failing this screening will not be used in any flight application.
Parts from lots exceeding 20% PIND failure should be reviewed by the GSFC.

13) PARTS TRACEABILITY

The Experiment developer should utilize traceability database(s) that provide the capability to retrieve historical records of EEE parts from initial procurement and receipt through storage, kitting, assembly traveler or production plan, test and final acceptance of the deliverable product. All EEE parts should be traceable to part manufacturer and lot/date code.

14) ORBITAL DEBRIS ASSESSMENT

consistent with NPD 8710.3, Policy for Limiting Orbital Debris Generation and NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris.

15) RETENTION OF TEST DATA AND SAMPLES

All builders of flight hardware should have a method in place for retention of data generated for parts tested and used in flight hardware. The data should be kept on file in order to facilitate future risk assessment and technical evaluation, as needed. In addition, the prime contractor and subcontractors should retain all part functional failures, all-destructive and non-flight non-destructive test samples, which could be used for future validation of parts for performance under certain conditions not previously accounted for. PIND test failures may be submitted for DPA, radiation testing or used in engineering models. Life test samples should be kept in bonded controlled storage. Parts and data should be retained for the useful life of the mission, unless otherwise permitted by the PCB. All historical quality records and those data required to support these records should be retained for a period of 10 years, minimum, and should be provided upon request.

16) INORGANIC MATERIALS

The Experiment developer materials list shall include an inorganic materials and composites usage. In addition, the experiment developer may be requested to submit supporting applications data.

17) MATERIALS PROCESS UTILIZATION

The experiment developer's materials list should include a utilization list. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings) should be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

18) MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the experiment developer, when selecting materials and lubricants, should consider potential problem areas. Examples are fasteners, radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum out gassing, toxic off gassing, flammability and fracture toughness, as well as the properties required by each material usage or application.

19) RELIABILITY

Experiment developers should work with the SET Reliability Engineer in support of the FMEA for their experiment.

20) RISK MANAGEMENT

The Experiment developer shall:

- Implement a continuous program to capture, acknowledge, and document reliability and quality risks before they become problems
- Analyze identified risks to estimate the probability of occurrence, severity of impact, timeframe when mitigation actions are needed, and classify into sets of related risks and prioritize
- Develop plans to implement risk mitigation strategies and actions and assign appropriate resources
- Track risks being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies
- Control risks by performing risk closeout, re-planning, contingency planning, or continued tracking and execution of the current plan
- Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the instrument/instrument-suit.

The following are guidelines, not requirements, for each experiment developer to follow in the development of their reviews.

A) TECHNICAL MEETINGS
B) EXPERIMENT REQUIREMENTS REVIEW
C) EXPERIMENT DESIGN REVIEW
D) EXPERIMENT PRE-ENVIRONMENTAL REVIEW
E) EXPERIMENT PRE-SHIP REVIEW
F) DESIGN DOCUMENTATION GUIDELINES

A) TECHNICAL MEETINGS

The Experiment developer should conduct informal internal peer reviews. The Experiment developer should produce peer review meeting minutes for documentation purposes. The experiment developer should keep these minutes. The minutes should include the following information:

- Review Presentation material, to include all errata
- Attendance List
- Action Items, including closure date and responsibilities

B) EXPERIMENT REQUIREMENTS REVIEW

The Experiment Requirements Review is held to assure that the objectives and requirements of the item being designed are understood and that the proposed approach will meet these requirements. The emphasis should be on the requirements, derived requirements, how they flow down, the proposed design concept and the definition of the interfaces. Detailed interfaces are a part of a later review. SET Carrier capabilities and SET Project expectations will also be discussed.

The review should address the following items: Science Requirements, Mission Objective; Investigation Requirements; Constraints; Technical/Performance Requirements; Organizational Interfaces; Technical Interfaces; System Drivers; Safety Considerations; Risk Areas; Proposed Design Approach (System Design, Mechanical, Electrical, Thermal, Software, Ground Support Equipment (GSE), Operations, Planned Test Program).

The plan is to conduct one review with all Experiment developers in attendance to assess the integrated operational constraints. This review will be held after contract award to support entry into the six-month Phase A design development.

C) EXPERIMENT DESIGN REVIEW

An Experiment Design Review should be conducted at a Critical Design Review (CDR) level at a time when it is probable that many experiments will have completed detailed design but haven't yet gone into manufacturing. SET experiments are not required to be at this level, and the information provided by experimenters at this review will indicate how far along experimenters are in the experiment development. Experiments may in fact be further along than CDR at the time of this review. If this is the case, it is recommended that these experimenters contact NASA at the time they believe they are ready for a CDR-level teleconference. The review should provide the SET project with design data and analysis to show an overall compliance with the requirements as specified in the SET Experiments Accommodations and Requirements Specification (SEARS), Mission Assurance Requirements Document (MAR) and other applicable documents prior to any design freeze and before any significant fabrication activity begins. At this review, NASA will go through a checklist type review in order to review all the experiments within a one (or perhaps two) daytime period. Each experiment should present the experiment design including (if applicable), the final design and interfaces by means of block diagrams, power flow diagrams, signal flow diagrams, interface circuits, layout drawings, software logic flow and timing diagrams, design language, modeling results, breadboard (and engineering model test results, if applicable).

Final estimates of weight, power, and volume are to be presented. Final calculations for mechanical loads, stress, thermal performance, radiation design and expected lifetime are to be presented. Final software requirements and updated system performance estimates should also be presented. Parts selection,

de-rating criteria and screening results, and the results of a Failure Modes and Effects Analysis (FMEA) are to be presented.

D) EXPERIMENT PRE-ENVIRONMENTAL REVIEW (PER)

Each Experiment developer will be required to conduct a Pre-Environmental Review prior to the start of formal environmental testing. The review shall enable the SET project to evaluate the planned test/calibration program and test flow to assure that it meets the program needs and to assure that a proper baseline of performance of the item to be tested has been established, and the item is ready to begin a qualification test program to demonstrate system performance. All performance liens, waivers, action items, malfunction reports and open items should be closed or disposition. Could-Not-Duplicates (CNDs) should not be closed and their discussion or risk assessment should include what fault tree was developed, possible causes, testing/on-orbit impacts, as well as "can we see it" in the follow-on test phases. The test verification matrix, including measurement tolerances, stimuli, contamination control, and facility readiness are to be presented. The results of sub-level testing, results since the last review, and results from the Comprehensive Performance Test (CPT) should be discussed along with the final results of any life tests. Failure free operating time on the item to be tested should be presented. Following a successfully completed review and the closeout of any remaining items, the hardware is ready to begin its environmental qualification or acceptance test program. The plan is to conduct one review for all Experiment developers (If the reviews are by teleconference, hard copies (electronic version acceptable). Documentation maturity will be evaluated appropriately at each review phase.

E) EXPERIMENT PRE-SHIP REVIEW (PSR)

Each Experiment should conduct a Pre-Ship Review teleconference with the SET Project prior to flight model delivery of the Flight unit to the Carrier. The documented results of environmental, system testing, calibration and end item performance are to be presented. The solutions to all problems encountered during the environmental test and validation program and the solution rationale are to be presented. Experiment data and all other data contained within the Final Acceptance Data Package should be reviewed to demonstrate compliance with all requirements. Experiments should also present plans for supporting integration and environmental test activities at GSFC, including post-delivery functional test requirements.

F) DESIGN DOCUMENTATION

The Experiment developer should deliver to the SET project design data for each review. This data should include design and analysis documentation, which ensures that the proposed design meets all the experiment, carrier interface, and qualification requirements. Within 5 days prior to the respective review, the design data should be made available to the SET project for inspection in the form of design review documents, schematics, assembly drawings, procedures, process documents, fabrication records, and flow diagrams. If the reviews are by

teleconference, hard copies (and/or electronic versions are acceptable) of the presentation package are to be provided to GSFC to use during these reviews. Documentation maturity will be evaluated appropriately at each review phase. At a minimum, the complete design data shall include the following:

- Functional capabilities, performance and margins
- Manufacturing flow diagram, including identified inspection points
- Parts List
- Materials and Process List
- Test plans and procedure commensurate with the review
- Drawing packages including but not limited to:
  - ELECTRICAL: schematics, artwork, assembly, and interface drawings
  - MECHANICAL: assembly and interface drawings

ACRONYM LIST

ADP	Acceptance Data Package
ABPL	As-Built Parts List
CCP	Contamination Control Plan
CDRL	Contract Deliverable Requirements List
CNDs	Could-Not-Duplicates
COTR	Contracting Officer Technical Representative
COTS	Commercial Off The Shelf
CSI	Customer Source Inspection
CDR	Critical Design Review
CPT	Comprehensive Performance Test
DPA	Destructive Physical Analysis
DR	Design Review
ESD	Electro-Static Discharge
FMEA	Failure Modes and Effects Analysis
GOTS	Government Off the Shelf
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
I&T	Integration and Test
IV&V	Independent Verification & Validation
LWS	Living With A Star
MAR	Mission Assurance Requirements

MOTS	Modified Off the Shelf
PER	Pre-Environmental Review
PAPL	Project Approved Parts List
PCB	Parts Control Board
PIND	Particle Impact Noise Detection
PL	Parts List
PPE	Project Parts Engineer
PSR	Pre-Ship Review
PWB	Printed Wiring Board
Q/ATP	Qualification and Acceptance Test Plan/Procedure
RR	Requirements Review
SEARS	Set Experiments Accommodation & Requirements Specification
SET	Space Environment Testbeds
SAM	Systems Assurance Manager
SMA	Safety and Mission Assurance
SQA	Software Quality Assurance